EFFECTS OF POPULATION DENSITY ON *CIMEX LECTULARIUS* L.

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Quaestiones entomologicae
5 : 9-14 1969

In C. lectularius, *population density affects fecundity and the duration of the nymphal stadia, the preoviposition period, and life, apparently through a contact stimulus. The effects reach optima at a population density of 4 to 8 insects/cm^2.*

Many studies have been made of the environmental factors that influence development and behavior of *C. lectularius*. Also, quantitative studies of natural populations have been conducted by Mellanby (1939) , Omori (1941), and Johnson (1942). Although the effect of population density on the physiology and ecology of many insects has received much attention, no detailed investigations have been carried out on *C. lectularius*. High population density, or overcrowding, is often accompanied by a shortage of food. The effect of food quantity free from the effect of population density was studied (Tawfik 1968). The aim of this study is to separate the effect of density itself from that of food quantity.

Overcrowding has a detrimental effect on insects in various ways; slower growth rate, increased mortality, smaller adults, and lower fecundity (Pearl and Parker 1922, Chapman 1928, Shannon and Putnam 1934, Bodenheimer 1938 and 1955, MacLagen and Dunn 1936, Crombie 1942, Robertson and Sang 1944, Terzian and Stahler 1949, Bar-Zeev 1957, Wada 1965). Most investigators have attributed the effect mainly to the mechanical disturbance of insects by each other. Some have demonstrated that most of these effects are dependent on the quantity and quality of food.

METHODS

Density ranging between 2 and 128 insects per surface area of 8 cm^2 of a piece of folded filter paper (2 x 2 cm) in 2 x 7 cm specimen tube was studied. Relating the density to the surface area of the folded filter paper is more important than relating it to the volume of the specimen tube because bedbugs are dorso-ventrally flattened, always aggregate on the surface of the folded filter paper, and thus essentially live in a two dimensional habitat. Data representing a density equal to 1 per 8 cm^2 was taken from Tawfik (1968) when the insects were fed till engorgement every 2 days. Eggs were taken from the standard culture and put in 4 x 4 x 1.5 cm plastic boxes. First instar nymphs were taken as soon as they hatched and were put in 7 x 2 cm specimen tubes together with 2 x 2 cm folded filter paper. Eight experiments were conducted in which the numbers of nymphs per tube were 2, 4, 8, 16, 32, 64, and 128 respectively (i.e. 0.25, 0.5, 1, 2, 4, 8, and 16/cm^2). In all the experiments the insects were allowed to feed on the second day after hatching and twice every week thereafter. For feeding, the insects from each tube were transferred to a 4 x 4 x 1.5 cm plastic box and were allowed to feed on human blood through organdie which covered a 3 cm diameter hole in the lid of the plastic box. Observations were carried out daily and the effects of the population density on the duration of the nymphal stadia, preoviposition period, fecundity, longevity, and mortality rate were studied.

With a constant food supply for the insects in all the experiments, the effect of population density could be due to either visual stimulus, olfactory stimulus, contact stimulus or combinations of these stimuli. All the experiments were conducted in the dark and the insects were exposed to the light only for ten minutes for examination to rule out the visual stimulus. An additional experiment was conducted to test whether the effect of population density is due to an olfactory or a contact stimulus. In this experiment 40 plastic boxes, similar to those used for feeding, were used. The lids of each 2 were glued together forming a combination of 2 chambers separated by the organdie on the inside of the lids. In one of these chambers a single first instar nymph was put with a piece of folded filter paper. In the other chamber 64 first instar nymphs were put. The insects were fed twice every week on human blood and the effect on the duration of the nymphal stadia of the single nymph was recorded. After the fifth moult two insects of opposite sex were put in one chamber instead of one insect and the effects on preoviposition period, fecundity, and longevity were studied. All the experiments were done at 80 F and 75% relative humidity.

On the Duration of the Nymphal Stadia

The effect of population density on the duration of the nymphal stadia is shown in fig. 1. Population density does not show a clear effect on the duration of the first nymphal stadium as this ranges between 3.6 and 4 days. On the other hand, the duration of the other four stadia decreased with the increase of population density. Olfactory stimulus does not seem to be involved in the effect on the duration of the nymphal stadia because there is no significant difference between the results of the experiment with the double chamber combination and those at density 1 and 2 (fig. 1).

On the Duration of the Preoviposition Period

The results are shown in fig. 2. Increasing the population density appears to decrease the minimum duration of the preoviposition period but beyond density 32 has no significant effect. Olfaction has no effect on the duration of the preoviposition period; the value obtained in this experiment does not show a significant difference from that when the population density was either 2 or 4.

On Fecundity

The relationship between the number of eggs laid per female and the population density is shown in fig. 3. Population density of 2 or 4 does not have a significant effect on the number of eggs laid per female. On the other hand, increasing the population density causes an increase in the number of eggs laid per female. This increase in the number of eggs reached a maximum when the population density was 64 and then decreased again. As shown in fig. 3, the number of eggs laid per female per day in the different population densities ranged between 2.1 and 2.4. Fig. 3 also shows that there is no olfactory stimulus involved in the effect of the population density on fecundity of the females.

On Longevity of the Adult Stage

Fig. 4 shows the effect of population density on the longevity of the adult stage. The longevity of both the female and the male increases with the increase in the population density. This increase in longevity reaches a maximum at a population density of 32 and then decreases with further increase in population density. There is no olfactory stimulus involved in the effect of population density on the longevity of the females or the males (fig. 4).

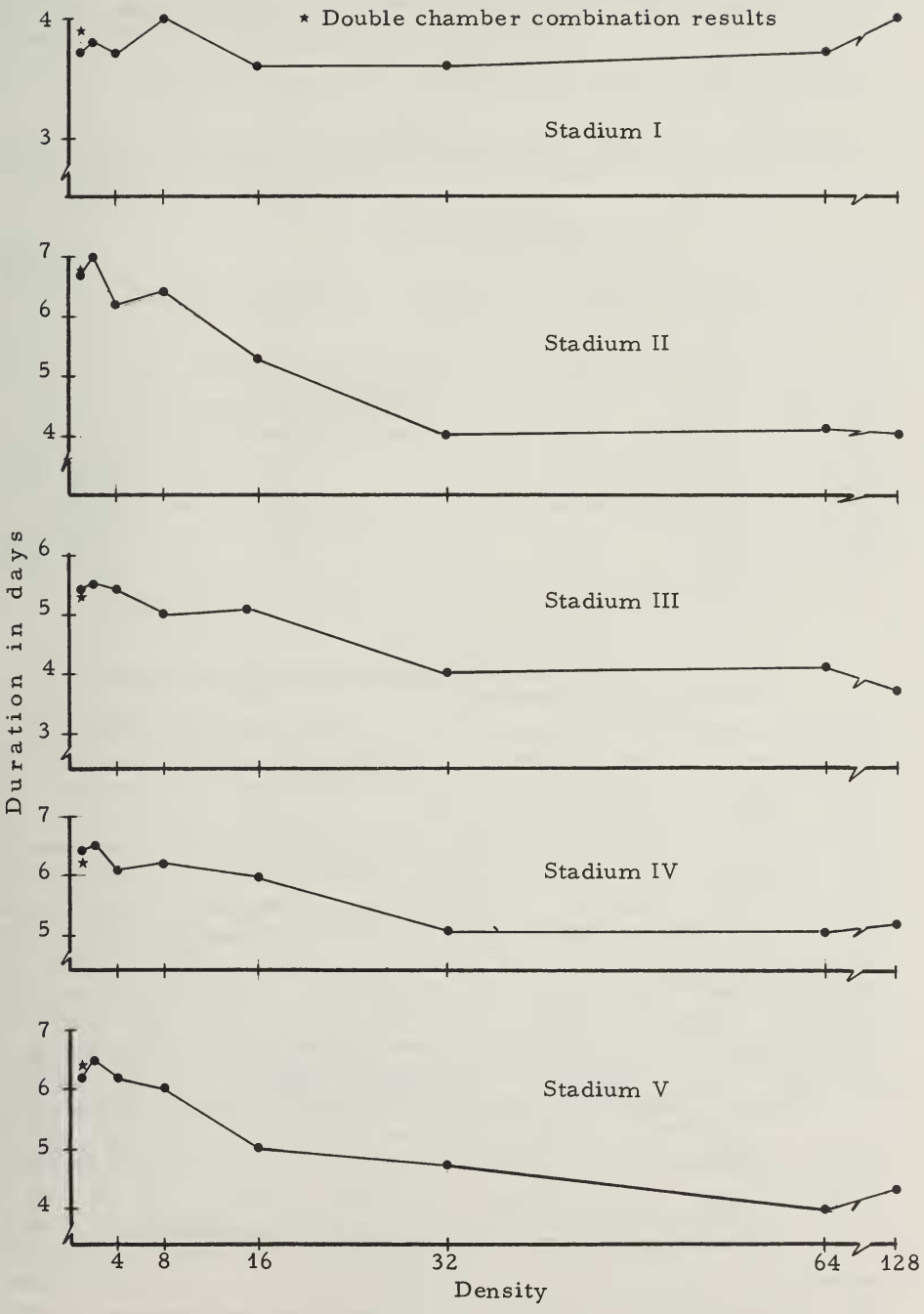

Fig. 1. Effect of population density of *C. lectularius* on the duration of the nymphal stadia.

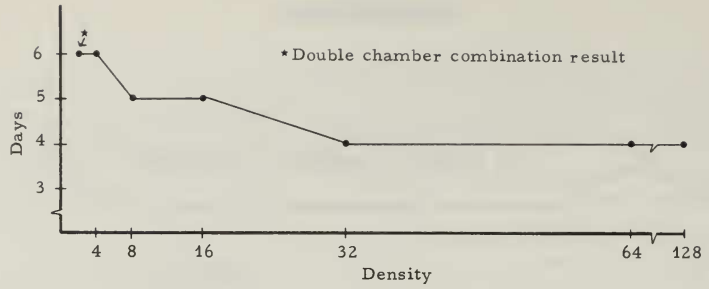

Fig. 2. Effect of the population density of *C. lectularius* on the duration of the preoviposition period.

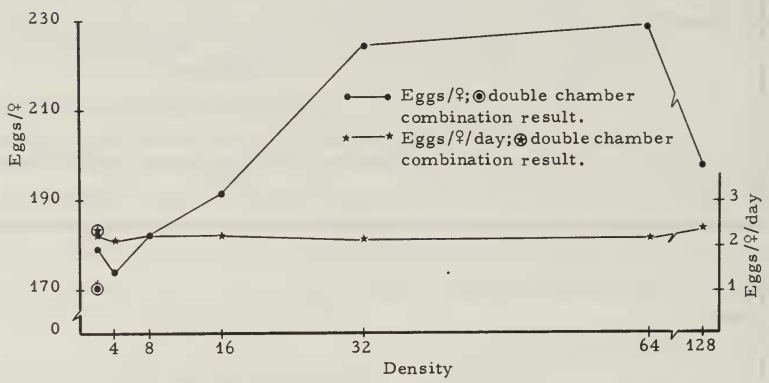

Fig. 3. Effect of population density of *C. lectularius* on the number of eggs laid per female and the number of eggs laid per female per day.

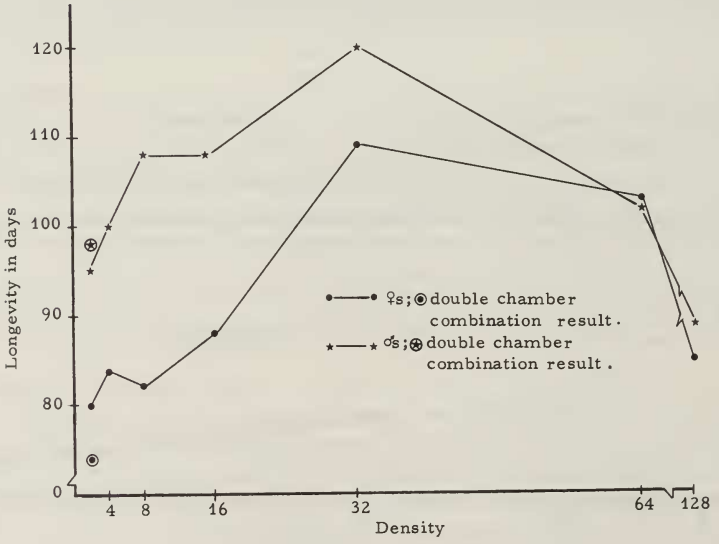

Fig. 4. Effect of the population density of *C. lectularius* on the longevity of males and females.

On Mortality Rate

Table 1 shows the effect of the population density on the percentage of mortality in the different instars of *C. lectularius*. Increasing the population density beyond 8 causes a decrease in the percentage of insects that reach the adult stage.

TABLE 1. Effect of population density on the percentage mortality in the different instars of *C. lectularius*.

Density	Percentage of the total died as					
	Instar 1	Instar 2	Instar 3	Instar 4	Instar 5	Adult
1	0	0	0	0	0	-
2	0	0	6.6	3.3	0	91.1
4	0	2.5	0	2.5	2.5	92.5
8	0	2.5	2.5	0	0	95.0
16	0	0	6.2	9.4	3.1	81.3
32	0	5.0	6.2	5.0	5.0	78.8
64	0	5.5	11.7	6.3	2.3	74.2
128	1.6	9.4	18.0	9.4	6.2	55.4

DISCUSSION

From these investigations the effect of population density on *C. lectularius* was apparent and it was clear that neither a visual stimulus nor an olfactory stimulus was involved in that effect. The effect of population density on the duration of the nymphal stadia, preoviposition period, fecundity, and longevity reaches an optimum at a population density of 32 to 64 insects per 2 cm^2 folded filter paper in 2 x 7 cm specimen tube. Population density seems to influence the bedbug through the stimulations of increased mutual contact. This influence was also suggested for mosquito larvae by Bar-Zeev (1957) and Shannon and Putnam (1934). However, Wada (1965) claimed that the situation seemed to be more complex and that neurophysiological processes might be involved. Duration of the nymphal stadia and the preoviposition period in the females decreased with the increase of population density. It is difficult from these experiments to specify the manner in which population density produces its effect through increased mutual contact. It seems that increasing the population density may increase the temperature of the microclimate as *C. lectularius* is always found in aggregates. This increase in the temperature may cause the decreases in the duration of the nymphal stadia and the preoviposition period.

Neurophysiological processes may also be involved, but more experiments are required to prove that. Such experiments should relate population density to endocrine activity, moulting, and reproductive functions. Although the number of eggs laid per female increased with the increase in population density to a maximum when the density was 64, it seems that this effect on fecundity resulted from the effect of population density on longevity of the adult stage rather than the effect of population density on fecundity, since there was no significant difference in the number of eggs laid per female per day at the different population densities.

ACKNOWLEDGMENTS

I am indebted to Professor B. Hocking, Department of Entomology, University of Alberta, for his guidance and stimulating discussions during the course of this work. I am grateful to the late Dr. R.L. Usinger of the University of California, Berkeley, who was my external examiner. I also wish to acknowledge the financial assistance of the U.S. Army Grant No. 63-G83 (Hocking trust) which made this study possible.

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